The Fouling of Mine Casing Surfaces by Fluorescent Organisms

Charles S. Yentsch and David A. Phinney
Bigelow Laboratory for Ocean Sciences
McKown Point, W. Boothbay Harbor, ME 04575
Phone: 207/633-9600 Fax: 207/633-9641 email: cyentsch@bigelow.org ;dphinney@bigelow.org
Award # N00014-98-1-0028

LONG-TERM GOALS

It is our goal to develop a comprehensive model for the estimation of the rate of attachment of benthic marine growth on the surfaces of mines deployed in shallow marine environments. The pivotal index, important to naval operations, is the point in time when there is no optical contrast between the mine surfaces and local benthic communities.

OBJECTIVES

Our objectives are to document the development of bio-fouling communities on mine casings in temperate and sub-tropical waters. We seek to answer the following scientific questions:

1) If a solid object like a mine casing is deployed in a climax community such as *Thalassia sp.*, what algal species initiate settlement onto the mine surface?

2) Since root systems are needed for seagrasses and not for macroalgae, what are the terminal species that will occur on the mine casing?

3) Are these communities optically distinct from the surrounding benthic community?

4) How rapidly does recruitment and succession occur?

APPROACH

Mine casings and control targets placed on the bottom off Boothbay Harbor, Maine, and Key West, Florida, were monitored for bio-fouling using a combination of standard white light and novel fluorescent photography obtained by SCUBA divers. A granite mooring block served as a control in temperate waters, a bleached coral patio block was used in sub-tropical waters. A Nikonos underwater camera and flash system was outfitted with a blue short-pass filter on the xenon flash unit and a red long-pass filter over the lens to record chlorophyll fluorescence from marine algae. White light and red fluorescence photographs were used to document the mine casings at time zero with no bio-fouling, and at regular intervals after deployment to determine the rate of recruitment onto the surfaces and the succession of plant and animal communities in relation to the controls and surrounding natural communities. The seasonal succession of benthic flora in sub-tropical waters has been outlined (see Seagrass Ecosystems, McRoy and Heifferich, 1977). The succession to algal climax communities such as *Thalassia sp.* depends on the substrate: the suite of species is different for hard, sandy and mud bottoms (Figure 1).

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**
4. TITLE AND SUBTITLE **The Fouling of Mine Casing Surfaces by Fluorescent Organisms**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Bigelow Laboratory for Ocean Sciences,180 McKown Point Rd, PO Box 475,West Boothbay Harbor,ME,04575**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM002252.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

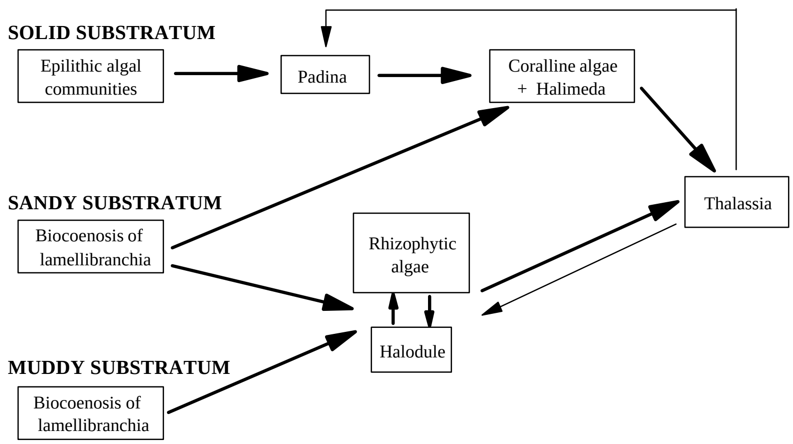

Figure 1. Scheme of the succession series leading to the *Thalassia testudinum* association. Thick arrows = progressive developments; thin arrows = regressive developments. After den Hartog (1973).

Each suite may be composed of diverse species of micro-, macro- and coralline algae. On sandy and muddy subtrates, initial recruitment is associated with bivalves (lamellibranchs). In temperate waters (Figure 2), initial recruitment is similar, but climax communities do not converge resulting in macroalgal covers on solid substrates and *Zostera marina* (eelgrass) or green algae covers on sediments.

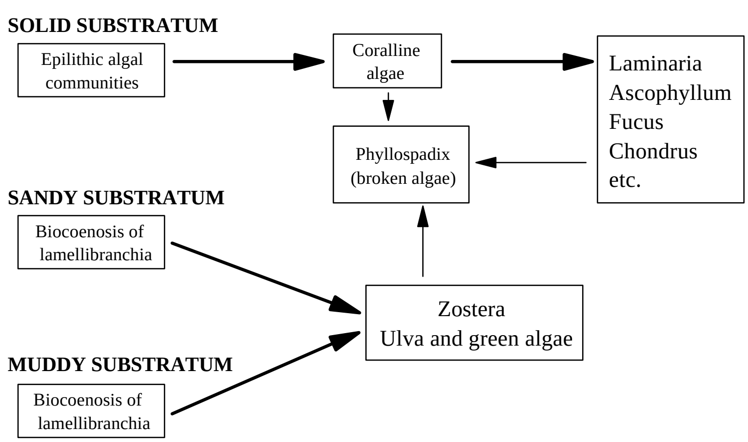

Figure 2. Scheme of the succession series leading to macroalgae or *Zostera* associations. Thick arrows = progressive developments; thin arrows = regressive developments.

WORK COMPLETED

Custom optical filter combinations and professional color films were selected and obtained for optimizing the fluorescence photography. By filtering the flash for only blue light, and placing a long wavelength red filter over the lens to isolate chlorophyll fluorescence, high speed films which exhibit sufficient red sensitivity are necessary for this application. We have obtained good results with Kodak MAX (ASA 800) and Ektapress Plus (ASA 1600) films. Experiments were performed in a pool using vails of chlorophyll in acetone and a Spectralon reflectance standard in order to determine the sensitivity and stray light characteristics of the camera system.

The mine casings, each consisting of an inert 500 pound projectile head measuring 8 inches in diameter and 4 feet long, were provided by Dr. Mike Strand of the Naval Surface Warfare Center, Coastal Systems Station in Panama City, FL. The casings were placed on soft bottoms in 15-20 feet of water surrounded by natural solid and sediment substrates, one off the dock at the NRL Marine Corrosion Facility in Key West, FL, the other off the dock at Bigelow Laboratory for Ocean Sciences in W. Boothbay Harbor, ME, in April of 1998. Time zero images were obtained at the time of deployment, the casings were inspected and photographed again after approximately four months. Color negatives were digitized using a Polaroid scanner and Adobe Photoshop software. Hardcopy products have been provided to ONR.

We have also used these techniques to document mine-like objects of different shapes, sizes and materials placed at the CoBOP site off Lee Stocking Island in the Bahamas. Time zero images were obtained in May of 1998, annual visits are planned as part of the CoBOP program.

RESULTS

We underestimated the rate that bio-fouling would be acquired at the Key West site, hence, we missed the early stages. After two months, the projectile casing was not visible to a divers eye looking down from the surface, close surveillance near the bottom was required to locate the casing. The same was true for the coral block control target. The surface of the casing and control were fouled with turf algae, but the major factor for reduction of contrast was due to an upward growth of surrounding seagrasses.

Water transparency and siltation rates are a problem at the Bigelow site. Both the projectile and the granite control target were significantly fouled with filamentous epilithic algae and settled debris after four months, significantly reducing their contrast with the surrounding benthic substrates. From other studies we know hat benthic microalgae (diatoms) colonize the bottom in these areas and are another primary recruiting species in this environment. However, climax macroalgae such as kelps and other browns found on nearby solid surfaces had not yet established themselves on the targets.

It is too early to claim that the den Hartog model will be useful for predicting the succession of algae on the surface of mines. In the sub-tropical experiment, the community on the mine casing after four months consisted ofa diverse assemblage of brown, green and red algal epilithic algae. Examination of other solid objects discarded into this area by NRL show changes in species diversity consistent with the den Hartog model as well as the recruitment of sponges and soft and hard corals. In the temperate experiment, the combination of water depth (sub-tidal) and turbidity limit the diversity of climax species to the Laminarian kelps which may require more than one growing season to establish significant cover.

Epilithic algae, benthic diatoms and siltation can optically mask solid objects over short time scales in the turbid waters.

IMPACT/APPLICATIONS

The differentiation of hard substrate bio-fouling by optical techniques in an area populated with a climax community is a reasonable proposition. Either reflectance or fluorescence techniques can be useful as long as the climax community does not present itself as a high standing community with an unbroken canopy. The species involved in succession have markedly different optical signatures from the climax species, in both albedo and fluorescence yield, which we suspect decrease as climax is approached.

TRANSITIONS

We are not aware of any transitions to industry, the fleet or persons in other countries. We find that both micro- and macroalgologists are interested in the succession problems. Larry Brand (Univ. of Miami) is an example of the former, Brian LaPointe (HBOI) the latter. Whether basic or applied reserach, we are all asking the same questions and searching for the methods to identify the sequence of succession. In both cases, the substrate problem is part of the general problem of eutrophication

RELATED PROJECTS

We have benefited greatly from discussions with members of CoBOP 6.1, specifically Ken Carder (USF) and Ken Voss (Univ. of Miami). Both of these colleagues have contributed through their research projects to the optical techniques we are using. The project has also gained technical expertise in underwater photography and image processing from Craig Quirolo of the non-profit Reef Relief in Key West, whose national and international reef photographic observational program is supported by NOAA and EPA. Brian LaPointe (HBOI) has been invaluable for identification of sub-tropical marine algae, his studies of Jamaican coral reefs are supported by the Jamaican government and the World Bank.

REFERENCES

Hartog, C. den. 1973. The dynamic aspect in the ecology of sea-grass communities. Thalassia Jugoslavica, 7: 101- 112.

McRoy, P.C. and C. Helferrich. 1977. Seagrass Ecosystems, a Scientific Perspective. Marcel Dekker, Inc., New York, NY., 287 pages.